CLAIMS

What is claimed is:

1. A method of determining a **smart antenna processing strategy** for a **remote user** to take into account **one or more interferers**, each interferer characterized by a **signature**, the **smart** antenna processing strategy applied to a **signal for transmission** to form a **set of antenna element signals** to transmit to the remote user from a wireless station that includes an array of antenna elements, or applied to a **set of received signals** from the set of antenna elements of a wireless station to process the received signals and obtain an **estimate of a signal transmitted** by the remote user to the wireless station, the method comprising:

   (a) providing a **process** that computes a **smart antenna processing strategy** for the remote user as a function of a **set of received data**; and

   (b) modifying the smart antenna processing strategy computed by the provided process by incorporating **interferer signature data** for each of the interferers related to the signature of each of the interferers such that the modified smart antenna processing strategy, if a downlink strategy, decreases the transmit signal strength in the direction of the one or more interferers, and, if an uplink strategy, decreases the sensitivity to signals from the direction of the one or more interferers.

2. The method of claim 1, wherein step (b) of modifying further comprises:

   (i) forming a **combination** as a **function** of the set of received data and interferer signature data for each of the interferers related to the signature of each of the interferers, the combination incorporating the interferer signature data such that a smart antenna processing strategy computed using the provided computation process with the formed combination as input, decreases the transmit signal strength in the direction of the one or more interferers if a downlink strategy, and, if an uplink strategy, decreases the sensitivity to signals from the direction of the one or more interferers; and

(ii) computing the smart antenna processing strategy by using the provided computation process with the combination formed in step (b) as input.

3. The method of claim 2,

wherein the strategy computation method has as inputs the set of received data, and an **estimate** of **one or more characteristic features** of the set of received data,

wherein the step of forming the combination forms a **modified feature estimate** of at least one of the characteristic features that the computation process has as input such that the modified estimate incorporates **an amount** of the characteristic feature of each interferer signature into the respective characteristic feature of the set of received data, and

wherein computing step (c) uses the provided computation process with the set of received data and the modified feature estimate as inputs.

4. The method of claim 3, wherein the amount is an **adjustable amount** defined by an **adjustable parameter**.

5. The method of claim 4, wherein the adjustable parameter for any interferer is selected to be a number sufficiently large to ensure that the carrier to interference ratio (CIR) reflected by the modified feature estimate is small.

6. The method of claim 4, wherein the adjustable parameter for any interferer is selected such that when the strategy computed by the strategy computation process is applied on the downlink the total transmit power is minimized while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

7. The method of claim 4, wherein when the strategy is applied in the downlink, the adjustable parameter for any respective interferer that is a co-channel user is selected to approximately maintain the same ratio of interferer power to remote user signal power reflected in the modified feature estimate as the ratio of respective interferer

power to remote user transmit power used to transmit to the respective interferer and the remote user, respectively.

8. The method of claim 2, wherein the step of forming the combination includes:

combining the set of received data and **an amount** of a **set of supplementary signal data** determined from each interferer signature to form a **combination signal data**.

9. The method of claim 8, wherein the amount is an **adjustable amount** defined by an **adjustable parameter**.

10. The method of claim 9, wherein the adjustable parameter for any interferer is selected to be a number sufficiently large to ensure that the carrier to interference ratio (CIR) of the constituent parts of the combination signal data is small.

11. The method of claim 9, wherein the adjustable parameter for any interferer is selected such that when the strategy computed by the strategy computation process is applied on the downlink the total transmit power is minimized while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

12. The method of claim 9, wherein when the strategy is applied in the downlink, the adjustable parameter for any respective interferer that is a co-channel user is selected to approximately maintain the same ratio of interferer power to remote user signal power in the combination signal data as the ratio of respective interferer power to remote user transmit power used to transmit to the respective interferer and the remote user, respectively.

13.]The method of claim 8, wherein the set of supplementary signal data determined from the interferer signature data includes random samples formed from the interferer signature data.

14. The method of claim 8, wherein the combining is by forming a sum of the set of received data and the amount of the set of supplementary signal data determined from each interferer signature.

15. The method of claim 8, wherein the combining includes performing a matrix factorization of the first set of received data and the signature data and combining the resulting factors.

16. The method of claim 1, further comprising

(d) estimating the signature of at least one of the one or more interferers to form the interferer signature data for the respective interferer.

17. The method of claim 16, wherein step (d) of estimating determines the maximum likelihood estimate of a particular interferer signature assuming no remote user signal and no other interferer signals are present.

18. The method of claim 16, wherein step (d) of estimating determines the maximum likelihood estimate of a particular interferer signature assuming the remote user signal and all other interferer signals are present.

19. The method of claim 16, wherein step (d) of estimating further comprises:

(i) Assuming some initial estimates for the signatures to be estimated.

(ii) repeating sequentially for each signature until all interferer signatures have been traversed, the step of

estimating the interferer signature while fixing the values of the remaining signatures to be the most recently determined estimate values, each of these fixed most recently determined estimate values initially being the initial value from step (d)(i), and thereafter being the values determined when this estimating step was last applied; and

(iii) iteratively repeating step (d)(ii) of sequentially estimating each interferer signature until convergence is reached.

20. The method of claim 1, wherein the interferer signature data for at least one of the one or more interferers includes a known signature for the respective interferer.

21. The method of claim 1, further comprising the step of:

applying the determined smart antenna processing strategy to process the a **signal for transmission** to the remote user.

22. The method of claim 3, wherein the characteristic feature estimate of the set of received data input in the provided strategy computation process includes an estimate of the covariance of the set of received data.

23. The method of claim 22, wherein the covariance estimate input in the strategy computation process is represented by a **noise-plus-interference-plus-signal covariance estimate**.

24. The method of claim 22, wherein the covariance estimate input in the strategy computation process is a **noise-plus-interference covariance estimate**.

25. The method of claim 22, wherein the combining step (b) includes forming a modified covariance estimate, forming the modified covariance estimate further comprising:

forming a **covariance estimate of the set of received data**;

forming a **covariance estimate of the interference signature data** of each of the interferers; and

summing the covariance estimate of the set of received data and the sum of the products of the covariance estimate of the second set of received data and an **adjustable parameter**.

26. The method of claim 22, wherein the combining step (b) includes forming a modified covariance estimate, the forming the modified covariance estimate further comprising performing a matrix factorization of the set of received data, performing a matrix factorization of the interferer signature data, and combining the resulting factors to form the modified covariance estimate, the relative amount of the factors in the combining defined by **an adjustable parameter.**

27. The method of claim 1, wherein applying the smart antenna processing strategy includes applying a **set of weights**, and wherein the smart antenna processing strategy

computation process computes the set of weights and the step of modifying produces a **modified set of weights**.

28. The method of claim 27, wherein the interferers are **other remote users** each having a **corresponding weight** for receiving from or transmitting to the wireless station, and wherein step (b) of modifying the set if weights includes for each of the weights of the set of weights for the remote user, for each interferer, adding a **constant** multiplied by the corresponding weight for receiving from or transmitting to the interferer.

29. The method of claim 28, wherein the constant for any interferer is selected to force the modified set of weights to be substantially orthogonal to the interferer signature.

30. The method of claim 28, wherein the constant for any interferer is selected such that when the modified strategy is applied on the downlink, the total transmit power is minimized while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

31. An apparatus for processing a set of received signals received from an antenna array of a wireless station or for processing a signal for transmission by from the antenna array, the apparatus comprising:

(a) a **processor** configured to compute a **smart antenna processing strategy** from a set of received signals to apply to received signals to determine an estimate of a **user signal** transmitted by a **remote user** or to apply to a **signal for transmission** to transmit the transmission signal to the remote user;

(b) a mechanism configured to modify the smart antenna processing strategy computed by the strategy computation process by incorporating **interferer signature data** for each of one or more **interferers**, each interferer characterized by a **signature**, the signature data related to the signature of each of the interferers, such that the modified smart antenna processing strategy, if a downlink strategy applied on the downlink, decreases the transmit signal strength in the direction of the one or more interferers, and, if

an uplink strategy applied on the uplink, decreases the sensitivity to signals from the direction of the one or more interferers.

32. The apparatus of claim 31, wherein the modifying mechanism (b) further comprises:

a **combiner** to form a **combination** as a **function** of the set of received data and interferer signature data for each of the interferers related to the signature of each of the interferers, the combination incorporating the interferer signature data such that the modified smart antenna processing strategy is determined by the processor with the combination as input.

33. The apparatus of claim 32,

wherein the processor has as inputs the set of received data, and an **estimate** of **one or more characteristic features** of the set of received data, and

wherein the combiner forms a **modified feature estimate** of at least one of the characteristic features that the processor has as input such that the modified estimate incorporates **an amount** of the characteristic feature of each interferer signature into the respective characteristic feature of the set of received data.

34. The apparatus of claim 33, wherein the amount is an **adjustable amount** defined by an **adjustable parameter**.

35. The apparatus of claim 34, wherein the adjustable parameter for any interferer is selected to be a number sufficiently large to ensure that the carrier to interference ratio (CIR) reflected by the modified feature estimate is small.

36. The apparatus of claim 34, wherein the adjustable parameter for any interferer is selected such that when the modified strategy computed by the processor is applied on the downlink the total transmit power is minimized while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

37. The apparatus of claim 34, wherein the adjustable parameter for any respective interferer that is a co-channel user is selected to approximately maintain the same ratio of interferer power to remote user signal power reflected in the modified feature estimate as the ratio of respective interferer power to remote user transmit power used to transmit to the respective interferer and the remote user, respectively, when modified smart antenna processing strategy is applied on the downlink.

38. The apparatus of claim 32, wherein the combiner is further configured to combine the set of received data and **an amount** of a **set of supplementary signal data** determined from each interferer signature to form a **combination signal data**.

39. The apparatus of claim 38, wherein the amount is an **adjustable amount** defined by an **adjustable parameter**.

40. The apparatus of claim 39, wherein the adjustable parameter for any interferer is selected to be a number sufficiently large to ensure that the carrier to interference ratio (CIR) of the constituent parts of the combination signal data is small.

41. The apparatus of claim 39, wherein when the modified strategy is applied in the downlink the adjustable parameter for any interferer is selected to minimize total transmit power while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

42. The apparatus of claim 39, wherein when the modified strategy is applied in the downlink, the adjustable parameter for any respective interferer that is a co-channel user is selected to approximately maintain the same ratio of interferer power to remote user signal power in the combination signal data as the ratio of respective interferer power to remote user transmit power used to transmit to the respective interferer and the remote user, respectively.

43.]The apparatus of claim 38, wherein the set of supplementary signal data determined from the interferer signature data includes random samples formed from the interferer signature data.

44. The apparatus of claim 38, wherein the combiner forms a sum of the set of received data and the amount of the set of supplementary signal data determined from each interferer signature.

45. The apparatus of claim 38, wherein the combiner is firther configured to perform a matrix factorization of the first set of received data and the signature data and to combine the resulting factors.

46. The apparatus of claim 31, further comprising

a signature estimation processor configured to estimate the signature of at least one of the one or more interferers to form the interferer signature data for the respective interferer.

47. The apparatus of claim 31, wherein the interferer signature data for at least one of the one or more interferers includes a known signature for the respective interferer.

48. The apparatus of claim 33, wherein the characteristic feature estimate of the set of received data input of the processor includes an estimate of the covariance of the set of received data.

49. The apparatus of claim 48, wherein the covariance estimate input of the processor is represented by a **noise-plus-interference-plus-signal covariance estimate**.

50. The apparatus of claim 48, wherein the covariance estimate input of the processor is a **noise-plus-interference covariance estimate**.

51. The apparatus of claim 48, wherein the combiner is further configured to form a **modified covariance estimate**, the forming of the modified covariance estimate including:

forming a **covariance estimate of the set of received data**;

forming a **covariance estimate of the interference signature data** of each of the interferers; and

summing the covariance estimate of the set of received data and the sum of the products of the covariance estimate of the second set of received data and an **adjustable parameter**.

52. The apparatus of claim 31, wherein the processor is configured to determine a linear smart antenna strategy by a **set of weights**, and wherein the modifying mechanism modifies the set of weights.

53. The apparatus of claim 52, wherein the interferers are **other remote users** of the wireless station each having a **corresponding weight** for receiving from or transmitting to the wireless station, and wherein the modifying mechanism is configured to, for each weight of the set of weights corresponding to the remote user, for each interferer, add a **constant** multiplied by the **corresponding weight** for receiving from or transmitting to the interferer.

54. The apparatus of claim 53, wherein the constant for any interferer is selected to force the modified set of weights to be substantially orthogonal to the interferer signature.

55. The apparatus of claim 53, wherein the constant for any interferer is selected such that when the modified strategy is applied on the downlink the total transmit power is minimized while the signal quality experienced by the remote user and at least one of the interferers meets or exceeds some prescribed quality of service.

ADD B2